by Laurie Curtis and Jana Fallin

Neuroeducation and Music

Collaboration for Student Success

Abstract: An expanding body of evidence based on cognitive neuroscience provides music teachers with information about the interaction of music instruction and brain development. This information is foundational for those interested in the biology of teaching in addition to the curriculum taught. Pedagogy can be grounded in research-based insights on how the brain learns and responds to experiences in the music classroom. This article offers a brief literature review about some elements of cognitive neuroscience that can inform pedagogical decisions; these include brain plasticity, multisensory instruction, executive functions, and memory. Also included are practical implications of the research and a discussion of partnerships within schools to best meet the needs of diverse learners.

Keywords: biology of teaching, brain plasticity, development, music, neuroscience, neuroeducation

Neuroscience research results can support the work and goals of music educators and their students.

There is a plethora of information and curricular materials marketed to teachers and schools that tout the term *brain-based*. That term can mean many things, and it is difficult at times to separate the information (the research base) from the misinformation (the marketing ploy). Music educators understand the importance of using current research to guide their instructional decisions, and cognitive neuroscience research is part of this knowledge base.

This article provides music teachers, administrators, and community stakeholders with a brief review of current research to help clarify the tenets of brain-based instructional practices related to music education. This will be framed through the field of study referred to as "neuroeducation"—a field blending psychology, "cognitive neuroscience" (how the brain processes thought), and teaching practices. In addition, we suggest clear steps to implement brain-based teaching through interdisciplinary teaching practices. This model will allow schools to use current school resources more effectively with an eye on the goal of having students become college and career ready.

Core Concepts of Neuroeducation

Neuroeducation examines the process of learning through many different lenses. It considers the way our bodies and brains physically respond to a learning event as

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well as the psychological implications involved in learning a task or applying a strategy. It also involves the pedagogical implications of retaining information for application in the future. The core concepts of neuroeducation to be briefly examined here include brain plasticity, the activation of attention and cognitive transfer, memory pathways, and multisensory instruction. A clear review of these concepts can help educators identify neuromyths—common misconceptions that surface when implications of music and cognitive impact are overstated and misinterpreted.[1] The implication of this misinformation is that program decisions made by schools or districts are often not founded on good science, yet they are accepted as instructionally positive for students.[2]

Brain Plasticity

The capability of the brain to change in structure and function due to experiences and input from the environment is known as brain plasticity.[3] Each new experience causes the brain's neural network to expand through the growth of dendrites sprouting from nerve cells in the brain. These dendrites electrically communicate information for processing through chemicals that enhance the electrical impulses the brain uses for communication, known as neurotransmitters. If information is experienced repeatedly, the brain becomes more efficient in this communication by building a fatty coating on the brain cell's axons. This fatty substance is called myelin, and its production is referred to as myelination. This process of myelination increases the brain's efficiency in processing and is therefore critical to the learning process.

Repeated exposure to a stimulus causes the brain to respond more quickly to that stimulus, enhancing learning, retention, and recall. The brain is actually changing, being molded by experience. This process is the foundation of learning. Educational consultants and staff development specialists Patricia Wolfe and Pamela A. Nevills state that in the area of cognition, young children are very responsive to instruction due to the fact that their brains are more receptive to new learning than in future years.[4] Beginning in the early years of a child's life, neural connections are made at a rapid rate. Doing what comes naturally to young children—singing, drawing, and playing—engage the young child in multisensory experiences that "wire" the brain for success.[5]

With each instructional event, new neural pathways are initiated or strengthened, connecting prior knowledge with new information. In a study of six-year-old students who were provided with fifteen months of instrumental music lessons (thirty minutes per day), it was found that behavioral and structural changes were evident in their brains (both in areas of auditory processing and sensorimotor skills) as measured by functional magnetic resonance imaging (fMRI) scans.[6] The changes indicated enhancement in the areas of the brain relevant to multimodal, sensorimotor skills, such as auditory processing and motor skills.

Studies suggest that intensive instrumental music instruction strengthens musically relevant auditory and motor neurosystems.[7] These auditory processing and motor planning systems are also critical to strengthening the basic skills of reading, writing, listening, and speaking to enhance multiple ways of accessing and expressing information. Results of brain-imaging studies have refuted the concept of hemisphere-specific left-brain or right-brain processing. It is now known that the cognitive demands of something as complex as language or music occur in both hemispheres as the brain seeks to make meaning from a musical event.[8] In support of this concept, professor of music psychology and biological psychology Stefan Koelsch has determined that when the human brain processes language and music, there are "overlapping cognitive mechanisms, in overlapping cerebral structures."[9]

Optimal learning occurs at critical or sensitive periods of brain development through interplay of both genetics and experience due to plasticity of the brain.[10] There are periods early in a child's life where basic aspects of musical behavior are more efficiently developed, such as the development of tonotopic maps (how the brain perceives tones). However, the brain still maintains the ability to make connections and grow in expertise as children age and become adults.[11] The music instruction that students are provided *at all ages* is capable of strengthening the neural pathways. The limits or relevance of the transfer will be defined by future studies, yet research has clearly shown that those trained in music have different brain activation patterns when engaged in listening activities than those that have not received such training.[12]

Cognitive Transfer and Activation of Attention

How do skills learned in the music classroom influence other cognitive tasks? Researchers note that near-transfer of skills, such as finger dexterity or rhythm analysis (when applied to related tasks), occurs when a student has been exposed to music education. A more difficult question to answer, however, is whether other cognitive skills are enhanced through listening to music. It is easier to identify a connection between experience and new learning with tasks that share somewhat similar cognitive skills (near-transfer effects). One possible near-transfer effect that has been identified as being increased or enhanced through music is attention.[13] Neuroscientist Devarajan Sridharan and colleagues suggest that listening to music enhances our ability to anticipate events and sustain attention while listening, a skill beneficial in multiple disciplines.[14]

A study conducted by researchers at Stanford University determined that when participants were involved in listening to music, both hemispheres of their brains worked in tandem, with the right hemisphere significantly more active, appearing to process the sound.[15] The brain exhibited increased activation (attention) when changes occurred, even anticipated changes signaled by periods of silence, sending new information to areas specific to working memory.[16] Jonathan Berger, one of the authors of the study, suggests that music may serve to sharpen

the brain's ability to anticipate events as well as sustain attention when receiving information.[17] The experience of listening to music can heighten the attention of the listener to anticipate upcoming information. This ability to engage in "active listening" is an important skill for students to possess. Although teachers have recognized the power of music to change one's state of mind, to excite or soothe, it is exciting to find that now brain imaging studies can provide scientific documentation of those changes.

Memory Pathways

Learning information is effective only if what has been learned can be retrieved as needed, when needed. Multiple memory systems are found to occur in the brain, and each one of the systems has different memory functions.[18] The semantic pathway processes new information through the use of words and basic conceptual understanding, such as the learning of terms for music composition and performance. A second pathway is the episodic pathway. It includes memories encoded through participating in an experience, such as students attending a concert or having a discussion with a musician. A third neural pathway is encoded through procedural learning, facilitated through doing something, such as playing a scale or tuning an instrument. The automatic memory pathway is encoded through repetition, such as in memorization of notes on a staff. The final neural pathway to enhance memory is called the emotional pathway, those memories that are often processed into long-term memory faster than other memories as they are encoded through intense emotional connection—musical experiences that trigger strong emotional responses.[19]

These memory systems are an integral part of how children and adults organize information, and while one might consider them different systems, they work together.[20] Information to be recalled at a later time must be seen as relevant and processed and organized in some way. Repetition in music is experienced through rehearsal, and the expected outcome is improved recall and increased retention of information.[21] The repetition of words placed within rhythm and rhyme is a common memory strategy that adults and children use within and beyond the music education classroom. It is easier for children to remember words if they have been repeated in the context of a rhyme.[22] These multiple memory pathways can serve to increase students' retention of information, leading to better recall in the future.

Multisensory Instruction

Learning occurs when strong pathways are formed between nerve cells, known as neurons. Multisensory instruction uses multiple senses at one time and provides the brain with multiple ways of "knowing" something.[23] Wolfe reported that exposure to music activates multiple areas of the brain in both hemispheres.[24] In fact, many musical experiences can activate the cognitive, visual, auditory, affective, and motor systems, depending on whether a person is reading music, playing an instrument, composing a song, beating out a rhythm, or just listening to a melody. Students in today's music classrooms are engaged in rich, multisensory experiences, and building strong, healthy neural pathways for learning.

These four core concepts of neuroeducation, including brain plasticity, activation of attention, memory pathways, and multisensory instruction, are easily evident in the music education experience. They speak to the contribution of music education to the overall learning experience of a student of any age. Brain plasticity allows for an educational experience to actually change the way our brains perceive and process information. As students rehearse a piece of music, their brains provide for more automatic responses, fluency of motion, and efficiency of performance. Attention is heightened in anticipation of the experience and repetition provides for strong retention of both processes of learning and content of learning. Music education has the ability to change brains, preparing students for a lifetime of learning. How might schools use the music education program to influence student learning in the most powerful way? It would seem through well-conceived collaborative efforts.

Neuroeducation Terms

axon: a long, slender projection of a nerve cell that transmits electrical impulses away from the nerve body

brain-based instruction: classroom teaching practices based on cognitive neuroscience research findings

brain plasticity: concept that the brain changes in structure and/or function due to experience

cognitive transfer: transferring learning between varying contexts; learning that transfers to another contextual situation

dendrite: a threadlike projection of a nerve cell that receives electrical impulses and sends them inward to the body of a nerve cell

myelination: coating of a nerve cell with myelin (a fatty substance) to increase the efficiency of neural transmission

neuron: nerve cell, especially one found in the brain and spinal column

neuroeducation: a field of study that blends psychology, cognitive neuroscience, and pedagogy

neurotransmitter: a chemical that serves to transmit the electrical impulses between neurons through a structure, allowing one cell to communicate with another using an electrical or chemical signal

Collaboration for Student Success

Collaboration for student success must occur at two levels—in both content and capacity. Collaboration in content can occur through interdisciplinary planning and collaboration in capacity through the shared expertise of music educators, and classroom teachers. Music educators Hansen and Milligan state it may be time to ask music educators how they might support the new accountability initiatives in our schools while continuing to teach the music curriculum with integrity.[25] The time may be at hand for

us to realize the power of the music teacher's role on collaborative teams to assist in designing instructional units of study that are multidisciplinary in nature and joyfully applied to the standards we teach. Consideration of the just-mentioned core concepts of neuroeducation allows us to see the benefits of having a music education component evident in collaborative interdisciplinary planning.

The silo model, where disciplines and grade levels often function very independently, does not allow for rich collaborative efforts. With the desire of becoming content experts, teachers often build up, maintain, and retain their own subject knowledge for use in their specific class or content area without intentional consideration of how their subject relates to the education of the whole child. At times overwhelmed with what they are required to do in the classroom, teachers may be teaching without knowledge or interest in what occurs down the hall. Unfortunately, this disjointed experience may be the daily reality of our students, hindering their ability to see connections between the curriculum and the "real world." Sharing of expertise between classroom teachers and music teachers would affect a change. We propose the following suggestions as a bridge across perceived barriers—allowing teachers to enact what they know about the power of music and its role in learning. Not all barriers will be removed, but they can be circumvented through thoughtful planning and hard work—hallmarks of good teaching.

1. ***Neuroscience findings about the critical importance of music's connection to increased learning must be shared with teachers, administrators, and community members.*** Sharing the lessons provided by cognitive neuroscience with those making curriculum and administrative decisions within schools is imperative. Music teachers should be engaging in action research in music classrooms, celebrating successes, seeking answers to questions from viable and reliable sources, and sharing their findings. Current research, such as that shared within this article, should be disseminated widely to inform school stakeholders of the known benefits of music education, as teachers can not act upon information they do not have.
2. ***Music teachers and classroom teachers should engage in purposeful sharing and dialogue regarding music and core teaching standards.*** It is important that music educators and classroom teachers become familiar with one another's standards to identify commonalities that will help them partner for the educational benefit of their students. In conversations and informal surveys, it appears that music teachers are often included in schoolwide initiatives that require them to become informed about content standards of other teachers in the school, specifically in the areas of reading and math. However, it is not as common for classroom teachers to be asked to review and study music standards. Opportunities for sharing music standards will allow teachers to recognize commonalities that exist for future collaboration and reinforcement of all teaching outcomes.

It is critical that we partner our understanding of our individual content standards with the greater picture of education for our students. For example, classroom teachers who are planning instructional lessons to build literacy fluency should be aware of the music standards for sentence fluency/rhythm and realize that the music teachers will be seeking an associated outcome when addressing the curricular standards for music. The human mind seeks to identify familiar patterns or structures when assimilating new information.[26] Conceptual understanding of patterns in kindergarten math curriculum begins with AB and ABB patterns represented in various ways, such as through colors, numbers, and pictures—why not through the musical patterns in a song? Teaching musical form would provide additional opportunities for intentional listening and auditory processing, which may enhance literacy learning. As districts seek to become familiar with the Common Core State Standards, the time is right for this type of exploration.

3. ***School leaders should facilitate collaborative, interdisciplinary planning for music teachers and grade-level teachers.*** Collaborative time must be planned in purposeful ways to allow for clear integration of resources. The antiquated model of grade-level teachers planning together while students attend "specials" eliminates opportunity for meaningful integration of curricular content with the arts. Jacobs challenges the way teachers have "met" in the past as grade levels or departments and suggests that teachers meet instead to solve a problem. Mariale Hardiman, a professor at the John Hopkins School of Education, and Martha Denckla, research scientist and professor of neurology, pediatrics, and psychiatry at the John Hopkins School of Medicine, agree, suggesting that it is time for integrated teaching methodology where, as teachers, we focus more on topics and problems than on specific disciplines.[28] The specifics of any interdisciplinary model will vary by district/school and may call for weekly faculty meetings to be teacher-directed work sessions rather than leader-driven opportunities for sharing information. Planning may need to occur at different times of the day and be facilitated by technology. Creative scheduling is needed to allow and encourage shared planning between classroom teachers and music teachers. A first step toward collaboration can be taken through shared online calendars, documents (such as Google Docs), and online planning tools that help teachers work together for a more cohesive educational experience for students.
4. ***Connections within curricula should be made explicit to students.*** The brain learns through connecting what is known with what is new. We need to help students understand more clearly the connections between what we teach and why it is of value for them to know and understand. For example, music can provide the "real-life" connection for much of our history and social studies content. It tells the stories of our lives and our ancestors with a different voice, and it allows students to find their voices to express themselves today through composing. Music has kept history alive when some were prohibited from writing or talking about what was happening in the world. We find examples of such in the spirituals, or songs of

freedom. As students learn about the civil rights movement, perhaps examining and then performing the songs of the period and the stories of those who wrote them can motivate students to think at a deeper level while they look at a specific time in history. Teaching fractions through a study of music notes and measures may provide classroom teachers with a way to get a difficult concept taught using a relevant tool of discovery, a song. Music can also provide a meaningful connection to science content, for example, when using the instruments of the school band or orchestra to study the concepts of vibration, pitch, and density. Music may be the common "glue" that can hold our splintered curriculum together.

Research Supports Your Efforts

Music is inherently valuable in its own right. However, there are other lessons to be considered, for example, how music can enrich and enhance learning in a broader sense. The research in cognitive neuroscience makes it clear that music's effect on brain plasticity and its ability to enhance attention, improve memory, and provide multisensory input provides promise in developing a more rigorous and relevant educational experience for our students. Music educators and classroom teachers can help to facilitate this positive change through collaborative efforts in interdisciplinary planning.

To meet the challenges of teaching in today's schools takes a new breed of teacher—a person interested in not only what we teach but also how the brain learns. A teacher with that knowledge can recognize "brain-based" materials and techniques as those that integrate what we know about how the brain biologically learns best. They can seek out teaching practices that highly engage students through multisensory input, challenging (but not stressful) events, and purposeful repetition of content that is relevant and meaningful to the learner. Albert Einstein once remarked, "If I were not a physicist, I would probably be a musician. I often think in music. I live my daydreams in music. I see my life in terms of music. . . . I get most joy in life out of music."[29] Teachers need to afford students the opportunity to learn as their brains learn best. That perhaps may be through music.

Notes

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